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Boundary Conditions, Data Assimilation, and Predictability in Coastal Ocean Models

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LONG-TERM GOALS

The long-terms goals of this research are to improve our ability to understand and predict environmental conditions in the coastal ocean.

OBJECTIVES

The specific objectives of this research are to determine the impact on coastal ocean circulation models of open ocean boundary conditions from Global Ocean Data Assimilation Experiment (GODAE) Pacific Ocean models, and to address closely related issues of uncertainty and predictability in coastal ocean models.

APPROACH AND WORK PLAN

The research will address the direct impact on coastal models of boundary conditions from GODAE large-scale models and two intermediate-scale models. The intermediate-scale models will have high-resolution atmospheric forcing, and boundary conditions from the large-scale GODAE model. The domain of the coastal model for the project will cover the 'coastal transition zone' (CTZ), which includes the continental shelf and slope, and the adjacent ocean interior. The CTZ, which extends offshore about 200 km in this region, is the natural oceanographic regime of interest for coastal modeling applications off Oregon and northern California. It is characterized by energetic wind- and buoyancy-driven flow over the shelf, accompanied by complex, lower-frequency eddy, jet and filament dominated flow over the slope and in the ocean interior, which is unlikely to be properly resolved by basin scale models. The impact on the CTZ-domain model simulations of assimilating satellite remote sensing observations, including sea-surface heights and temperatures, and of using scatterometer wind stress fields, will also be addressed. Validation of the simulated coastal ocean circulation will be provided by existing elements of the Oregon coastal ocean observing system, including short-range and long-range coastal HF radar arrays, and by extensive in-situ data sets from major observational programs during 2000-2003. The impact of the boundary conditions will be assessed quantitatively through data assimilation, using a variational representer-based generalized inverse method. The closely related issues of uncertainty and predictability in coastal ocean models will be addressed using a variety of empirical and theoretical methods to study disturbance growth mechanisms and to develop uncertainty budgets for these models.

In addition to PIs Samelson, Allen, Egbert, Kindle, and Snyder, other senior personnel are A. Kurapov and R. Miller, both at College of Oceanic and Atmospheric Sciences, Oregon State University. Dr. Scott Springer has been hired as a full-time research associate to pursue the physical circulation modeling, data assimilation and boundary condition assessment studies, with guidance and collaboration of Allen, Egbert, Kurapov, Miller (OSU) and Kindle (NRL). Samelson (OSU) and Snyder (NCAR) are currently advertising for a postdoctoral investigator, who, with their guidance and collaboration, will be primarily responsible for the predictability and uncertainty studies. All investigators will share responsibility for the synthesis tasks.

The work plan for the remainder of Project Year 1 includes: completing the construction of a nested CTZ-domain model based on the ROMS (Regional Ocean Modeling System) primitive-equation ocean modeling code, and completing and evaluating the associated forward model runs using various atmospheric forcing products and boundary conditions: testing and modifying as necessary the ROMS tangent linear and adjoint codes for the CTZ domain; implementing and testing covariances for open boundary errors; and computing the linear and nonlinear response to perturbations using long DA hindcasts in the shelf-domain configuration. In Project Year 2, work is planned also to begin on analyzing shelf, slope, and CTZ circulation processes; assimilating satellite data and comparing the impact of different boundary condition formulations, error covariances, and sources of boundary data, with validation from in-situ data; testing methods for extending assimilation run times; and analyzing optimal disturbances, bred vector growth and adjoint boundary condition and forcing sensitivity in shelf- and CTZ-domain configurations.

WORK COMPLETED

Since the GODAE Pacific HYCOM model at present is not yet functioning with full data assimilation capability, we have decided, in consultation with NRL partner John Kindle, to proceed with nesting the

CTZ-domain ROMS model in the NRL regional NCOM-CCS (Navy Coastal Ocean Model-California Current System) model. The latter regional model is nested in the NRL real-time Global NCOM model, which is the present Pacific Ocean GODAE system. Both Global NCOM and NCOM-CCS include assimilation of satellite altimeter and sea-surface temperature measurements. NCOM-CCS has higher horizontal grid resolution than Global NCOM (9 km vs. 12 km) and, in addition, is forced by atmospheric fluxes from a high-resolution COAMPS (Coupled Ocean Atmospheric Mesoscale Prediction System) reanalysis product. NRL partner John Kindle has provided the OSU investigators with NCOM-CCS model output for years 2001 and 2002, along with COAMPS forcing fields. The NCOM-CCS model results are presently being compared with in-situ measurements from the extensive COAST (Coastal Ocean Advances in Shelf Transport) 2001 and GLOBEC/NEP (Global Ocean Ecosystem Dynamics/Northeast Pacific) 2002 field experiments. Construction of an initial version of the ROMS CTZ model has been completed and research on implementation and testing of nesting methods has been initiated.

RESULTS

Preliminary results from model/data comparisons offer encouragement that the resolved offshore California Current flow fields in the NCOM-CCS model are well enough represented to provide physically important outer boundary conditions for the higher-resolution nested ROMS CTZ model.

IMPACT AND APPLICATIONS

National Security

The primary potential future impact of this project on National Security and Homeland Defense is improved understanding of and predictive capability for coastal ocean environmental conditions to assist security and defense operations in these regions.

Economic Development

The potential future impact of this project on Economic Development includes the stimulation of new business opportunities in coastal environmental prediction, based on improved understanding and predictive capability.

Quality of Life

The potential future impact of this project on Quality of Life includes better management of the coastal zone for public and ecosystem health, and resource extraction and sustainability, based on improved understanding of and predictive capability for coastal ocean environmental conditions.

Science Education and Communication

The potential future impact on Science Education and Communication includes better education of future research scientists, policy makers, and the general public, based on improved understanding of the coastal ocean.

RELATED PROJECTS

The model results obtained in the project are being compared with in-situ measurements from the National Science Foundation Coastal Ocean Processes/Coastal Ocean Advances in Shelf Transport (CoOP/COAST; http://damp.coas.oregonstate.edu/coast/) and Global Ocean Ecosystem Dynamics/Northeast Pacific (GLOBEC/NEP; http://globec.coas.oregonstate.edu/) field experiments.